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EDITORIAL.

IN almost every paper read before the Institution the importance of co-operation between the designer and the producer is emphasised. It is surprising that this subject has so long escaped notice as the obvious starting point for the production engineer in all his efforts to cheapen, improve, or increase output.

Evidences of the economies which may be effected in this direction are not far to seek. Almost any present-day engineering products, and particularly some of the highest conceptions of engineers from the point of view of theoretical design and efficiency, lose much of their commercial attractiveness when they are critically examined by a competent production engineer. Even a casual glance suffices to show that simple, accurate, and straightforward methods of production have been either entirely ignored by the designer, or else he has regarded such matters as minor considerations. Unless checked at the outset, this attitude of mind on the part of the designer gives rise to innumerable difficulties and sources of inefficiency in the shops.

The most obvious direction in which the designer can assist the production engineer is in the matter of manufacturing tolerances. Undoubtedly these should be fixed, not only with regard to the ultimate functioning of the mechanism, but also in collaboration with the production engineer himself. Perhaps next in order of importance is the method of dimensioning a works drawing. To the designer this may seem a trivial matter, but not to those concerned with planning and tool design. A suitable datum face, convenient alike for location and for inspection by straightforward, reliable methods, is of paramount importance.

FEATURES OF MACHINE TOOLS THAT MAKE FOR INCREASED PRODUCTION.

By Mr. G. W. Rawlings of Messrs. Associated British Machine Tool Makers, Ltd.

THIS paper is intended to cover not only those features of machine tools that are conducive to increased production, but also to improved production, since in many cases output could be increased at the expense of quality, which would be undesirable. The features to be discussed, therefore, are those that increase the rate of output whilst maintaining the existing quality, or, alternatively, that improve the quality whilst maintaining the same rate of output.

Modern high-grade machine tools have certain features in common which may be regarded as standard to each type. In machines produced by reputable makers these may be considered to be uniformly excellent, and it is, therefore, not in these features that the production engineer is particularly interested. On the other hand, various makers have developed individual features and refinements that may improve or increase production, and it is these with which we propose to deal. The subject may be conveniently considered under the most common groups of machines, such as radial drilling machines, centre lathes, capstan and turret lathes, milling machines, grinding machines, reciprocating machine tools, etc.

Radial Drilling Machines.

As a modern machine tool, the capacity of the radial drilling machine on certain classes of work is unassailable, and it is only a lack of appreciation of its qualities that has prevented it from occupying a much more prominent place in the average machine shop. Its particular field, namely, the drilling, reaming, tapping, etc., of holes in pieces of work which are not easily moved beneath a fixed spindle, covers a much larger range than is apparent at first sight. On radial machines of a decade ago the advantage over a fixed spindle drilling machine was scarcely apparent except for very heavy work. The traversing of the spindle saddle along the arm, and the elevating or lowering of the arm on the column of the old type machines, were frequently slow and laborious operations. It follows that the most valuable feature of the modern radial is the ease with which it may be controlled, and the tendency to centralise control levers is perhaps more apparent here than on any other type of machine tool.

Machines are now made in which practically every motion can be controlled from the saddle by the operator in his normal working position.

In considering the control of these machines the necessary operations may be classified as follows :—

1. Adjustment to various parts of the machine to bring the drill into its working position.

2. Adjustment of gears, clutches, etc., to obtain a correct spindle speed.

3. Adjustment to the feed.

4. Adjustment to start, stop, or reverse the spindle.

A number of slides were shown to illustrate the various methods adopted to minimise the time and energy required to make the above adjustments.

The adjustment of the arm itself and of the saddle along the arm are two movements that can be performed simultaneously. To add to the rigidity of the drill for heavy work it is advisable to lock the saddle and arm rigidly in the adjusted position. This increases the efficiency of the machine, since vibration is reduced to a minimum, whilst the spindle alignment is maintained, with advantages which are reflected in the life of the cutting edges of the tools and in the accuracy of the work produced. It is in the action of locking the saddle and arm that the most important development has been effected, this double lock being controlled by a single lever. In the older type of machine, where the arm could only be locked on the pillar by means of levers near the pillar itself, the operator was likely to forego the added rigidity secured by the lock on account of the inconvenience and time taken in moving from his operating position to manipulate the lever. In the modern machine the single lever is situated immediately beneath the saddle in the most convenient position for locking up the entire machine with a single movement.

Another movement necessary in adjusting the spindle is the elevation of the arm. This is now effected by a lever which controls the power elevating and lowering mechanism, and in addition operates the arm locking device, being so arranged that it is impossible to operate the elevating gear whilst the arm is locked to the sleeve.

It is probably in the adjustment of gears, etc., that the modern radial has been most highly developed beyond its prototype of ten years ago. Machines of that period, and indeed many machines of to-day, are fitted with either a cone pulley or gear box mounted on the base plate at the foot of the column. This arrangement required the operator to move from his position and stoop down to effect the necessary change in spindle speed. By the introduction of speed gears and change mechanism on the saddle this handicap to maximum production has been removed, whilst the

added advantage is obtained of a constant speed for all driving shafts up to and including the horizontal arm shaft. With reference to feed control, this has been brought to a state of maximum convenience on the Archdale machines. The drill is first brought down rapidly to the work by means of a star wheel, after which the feed is engaged by means of a handle conveniently situated. In the lighter machines a sensitive lever may be used, whilst for the fine hand feed a handwheel is employed. Feed changes are obtained by the operation of feed selection levers, and an automatic stop motion is fitted which can be set to trip the feed at any position of the spindle.

Progress in design is also evident in the method of starting, stopping, and reversing the spindle. In place of a belt or gear reverse lever situated at the back of the column the control of the drive is now effected by a lever placed immediately beneath the saddle. The extreme positions of this lever (about 25 deg. apart) give the forward and reverse drives respectively, whilst the central position brings the spindle to rest.

To illustrate the value of these features of centralised control, a test was recently carried out with the object of comparing a modern centralised control machine with another radial drill having the usual gear box at the foot of the pillar, and separate saddle and arm locks. The results of the test are given in the accompanying table, the machines being timed in detail on drilling and tapping holes in a box form casting using a jig. It will be observed that the centralised control machine showed an improvement of approximately 39 per cent. in the rate of production without, of course, any deterioration in the quality of the product.

An important aspect of this matter of centralised control which is sometimes overlooked is that the operator, in his desire to increase output and avoid fatigue, will almost invariably take the obvious course of neglecting such movements as are required to lock the sleeve to the pillar or to change the spindle speed when the difference is not very apparent. Such neglect leads to poor workmanship and damaged cutting tools.

Another feature on modern machines is the use of spindles having six keys or splines machined from the solid. This construction ensures long life and considerably increases the output obtainable from a given diameter of spindle. Spindle sleeves are also now made with the feed rack cut solid, so that the troubles invariably associated with separate inserted racks are eliminated. Ball bearings are also used extensively in the construction of radial drilling machines, and the advantages of these and of constant high speed shafts with gears and other components of commensurate size can only be fully appreciated after careful investigation. It has been definitely proved, however, that the efficiency of the

drive in heavy duty radial drills has been increased by as much as 60 per cent. by the introduction of these features.

On heavy work the present demand for higher output undoubtedly militates in some directions against high-grade work.

	Centralised Control Machine.	Other Machine.
	Seconds.	Seconds.
Insert drill, move saddle and arm into working position, lock saddle and arm, move drill to work, start spindle and engage feed	17	26
Centre six $\frac{3}{4}$in. tapping holes, moving arm and saddle and locking each five times ..	85	110
Change drill, change speed, move and lock	25	44
Centre four $\frac{1}{2}$in. tapping holes, moving arm and saddle and locking each three times	43	62
Drill two $\frac{1}{2}$in. holes, moving and locking arm and saddle	36	50
Change drill, move and lock arm and saddle	21	30
Drill two $\frac{9}{16}$in. holes and lock arm and saddle	59	68
Change drill, move and lock arm and saddle	33	38
Centre four $\frac{7}{16}$in. tapping holes, moving arm and saddle and locking each three times	32	51
Change drill	10	10
Drill four $\frac{7}{16}$in. tapping holes, moving and locking saddle and arm three times	54	92
Change drill, move and lock arm and saddle	18	34
Drill four $\frac{1}{2}$in. tapping holes, moving and locking arm and saddle three times ..	86	116
Change drill, change speed, move and lock arm and saddle	20	46
Drill six $\frac{3}{4}$in. tapping holes, moving and locking arm and saddle five times ..	149	250
Change drill for tapper, move and lock arm and saddle	30	45
Tap six $\frac{3}{4}$in. holes, moving and locking arm and saddle five times	132	256
Change tapper, move and lock arm and saddle	17	28
Tap four $\frac{1}{2}$in. holes, moving and locking arm and saddle three times	78	128
Change tap and move arm and saddle, locking each	8	21
Tap four $\frac{7}{16}$in. holes, moving and locking arm and saddle three times	65	130
	16m. 58s.	27m. 15s.

Here, again, when the movements necessary to ensure high quality adversely affect production, there is great risk of their being omitted or neglected. With the object of making the locking operation as simple as possible, therefore, machines have been introduced in which all possible movements are interconnected. The Asquith patent triple lock provides a good example of this practice. In this case the motion is obtained by means of a single lever which locks the saddle to the arm, the arm to the sleeve, and the sleeve to the internal column. All drilling operations can therefore be performed with reasonable certainty that the machine is operating under the most desirable conditions for securing accurate results.

Another interconnected motion is fitted on the girder radial drills manufactured by the same firm. In this case the locking of the saddle on the arm, and the arm on the column is effected by the same lever which engages the power feed. In operation the spindle is adjusted quickly to the desired position for drilling, with the quick hand feed, and at the required point the selected feed motion is engaged by a movement of the lock lever. Thus the locking operation cannot be accidentally omitted.

Other interesting features are embodied on the same type of machine. For example, the power feed can be applied so lightly that it will slip to prevent the breakage of the smallest drill, or it can be applied to drive large drills up to their full capacity. In the case of machines fitted with reversing motion for tapping, the friction feed can be disengaged independently of the locking motion, so that the quick hand vertical adjustment is available.

The Auxiliary High-speed Spindle.

To drill efficiently all the holes in one piece of work it is necessary that the work should be carried out at a single setting if possible, and should there be holes of widely different size it is probable that the range of spindle speeds, although usually adequate for large drills, will not enable very small drills to be run at the correct speed. To overcome this difficulty a high-speed spindle of the type introduced by Messrs. William Asquith (1920), Ltd., may be used. This consists of a main spindle similar to the standard spindle on the machine, together with a second smaller spindle which is geared to the first member so that it revolves at three times the regular spindle speed. This spindle can therefore be used for small holes, which are usually drilled on a sensitive radial at a second setting.

A further economy may also be effected by using the high-speed spindle to drill preliminary small holes, which are afterwards opened out by the larger drills. As is well known, the broad point of a large drill has no true cutting action, so that when drilling from the solid a large drill absorbs considerable power

besides increasing the feed pressure and limiting the rate at which the drill may be fed. To take full advantage of this practice provision has been made on the machine for adjusting the main spindle exactly over the hole drilled by the small spindle without loss of time.

Tilting Worktables.

In many workshops it is noticeable that, whilst full advantage is taken of the latest developments in high-speed cutting steels,

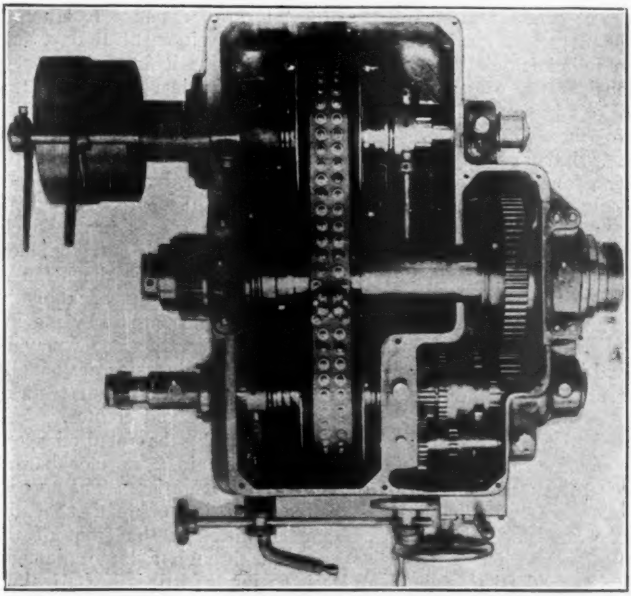

Fig. 1.—A variable speed headstock.

etc., the aggregate efficiency of machine tools remains comparatively low owing to the idle periods entailed in setting up work, etc. Loss in this direction can be minimised by utilising radial machines with multiple base plates so that the work can be set on one side whilst other work is being drilled.

Another device which is being extensively used for the same purpose is the universal worktable, by means of which work may be drilled, reamed, tapped, and faced from all directions, except, of course, that of the face which is in contact with the table.

This table consists essentially of a strong and rigid casting which can be revolved on trunnions carried in suitable supports. The axle is rotated in either direction by a handwheel operating through worm gearing, stops being provided for indexing to 45° or 90° on either side of the vertical as required. In addition to the advantage obtained by minimising the time required for work setting, a further desirable point in the use of this equipment is that resetting errors are avoided.

Centre Lathes.

The centre lathe being the oldest form of machine tool known has naturally reached a high state of development to-day. As an indication of the trend of modern design it is of interest to consider the present products of one of the largest machine tool makers in the world who are devoted exclusively to the production of lathes, *i.e.*, Messrs. John Lang & Sons, Ltd. This firm build their lathes with three different types of headstock, the triple gear four-step cone headstock, the twelve-speed all-geared headstock, and their patent variable-speed headstock. The triple gear cone headstock has a range of twelve speeds progressively graded with a single-speed counter motion. Perhaps the most interesting feature in the design of this machine is the arrangement of the gearing at the front instead of at the back of the headstock, as is usually the case. It is claimed that, by placing the gearing at the front of the headstock, cutting tools may be used in the front position with the same advantages as are usually secured by the average turner who inserts heavy form tools or important cutting tools in the back post to avoid chatter.

In the twelve-speed, all-geared headstock, the required speed is obtained by positioning the four levers in a selector bar so that the speed changing is quite a simple operation. The general arrangement of the gears is similar in principle to that of the cone headstock, inasmuch as they are fitted at the front of the headstock. The drive is transmitted through a large diameter taper coned friction clutch which is spring loaded, is self-aligning, and has metal-to-metal driving faces. This clutch runs at a constant speed of 400 r.p.m., which gives a relatively high peripheral speed, so that even at the fastest spindle speed a slight reduction takes place through the driving gears. The control levers are interlocked, so that it is impossible to engage conflicting gears, whilst a speed index plate is so placed that the spindle speed may be seen at a glance. Time is saved and damage to the headstock is obviated by the provision of a Ferodo-lined brake which is automatically brought into action by the movement of the levers, so that the clutch is disengaged and the brake applied before changing gears.

Other useful points in this design are that the free position

of the spindle is obtained through the medium of the lever nearest the working position of the operator; all gears run in oil; no gears are in mesh unless transmitting power; sliding gears are fitted to large diameter splined shafts.

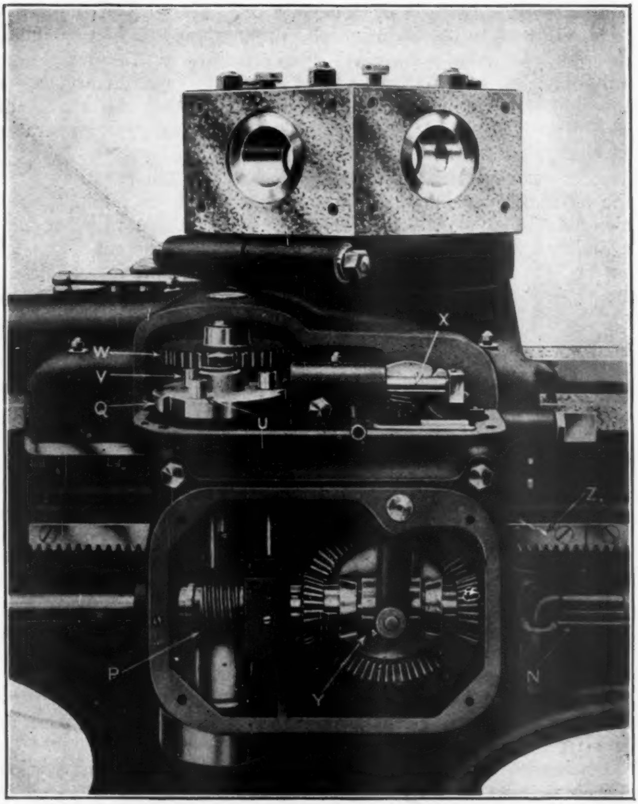

Fig. 2.—Quick power traverse and turret indexing mechanism.

Variable Speed Headstock.

Although not commonly adopted in lathe design, the variable speed headstock presents many points of interest. The construction is comparatively simple, the main features being shown in fig. 1. Headstocks of this type are particularly useful on wide

facing cuts, since the speed can be varied gradually during the cut without resulting in a ridge such as is usually produced by any attempt to change speed during the traverse of the facing cutter. The drive through this headstock is taken from the fast and loose pulleys on the right and transmitted from the lower pulley to the gearshaft by a flexible belt, after which the motion is transmitted to the main spindle through the medium of double or triple reduction gearing. The wheels carrying the flexible belt drive consist of two flanges, one of which is stationary, whilst the other is free to slide longitudinally along the shaft, the movement being controlled by means of a hand wheel operating through a worm and quadrant.

This mechanism is so arranged that as one flange pulley closes the other one opens by the required amount to maintain the tension of the belt, and provide a variation in the ratio of their effective driving diameters. The end thrust of the cones is taken by ball thrust washers. It will be apparent that, in addition to the variation obtained by the movement of the flange pulleys, the use of the double or triple gear provides a further range of speed. An index plate suitably graduated shows the spindle speed corresponding to any particular setting. To enable the tension of the belt to be maintained, independent adjustment is provided for the moving flanges.

Amongst the most important features of general design, the method of guiding the saddle on the bed is always of interest. The tendency amongst the most reputable makers seems to be to adopt the narrow guide bed, which certainly possesses many advantages over the type in which the saddle is guided by means of two angular faces widely spaced. In the old design it may be noticed that adjustment for wear is effected by tightening the bolts that clamp an adjusting strip against the angular faces, and there is a tendency to spring the two sides of the bed inwards. Moreover, the bearing in the saddle cannot be made more than one and a half to twice the length of the overall width between the guide faces, an obvious defect which is accentuated by the distance between the centre of the lead screw or rack and the centre of the bed.

Obviously, this construction gives the worst possible conditions for obtaining true alignment of the saddle. In the more recent design the saddle rests on three upper surfaces, and is guided along the bed by square faces on a narrow front shear. A space is left at the edge of the opposite shear to ensure that there is no bearing on this edge, retaining plates being fitted to prevent any lift of the saddle whilst cutting. Adjustment for wear is a simple matter, and entails no possibility of spring in the metal between the guide faces, whilst it is easily possible to make the length of the guide equal to ten times the width. Further, the

distance between the lead screw and the centre of the guiding shear is very small, so that the tendency to twist the saddle on the bed is reduced to a minimum.

Centralised Control Apron.

The principle of centralised control has latterly been applied to lathes, the engagement of the self-acting, sliding and surfacing feed motions on Lang lathes being obtained by means of separate worms carried in a new design of drop worm box. The outstanding feature of this box is that it is pivoted in the main body of the apron, so that it drops out in a plane parallel to the axis of the lathe, thus giving instantaneous engagement or disengagement of the required motion. Further, either the self-acting sliding or surfacing motion can be engaged by suitable movement of a single handle, whilst an interlocking device is fitted to prevent the engagement of conflicting motions. This is so arranged that when screw cutting neither the sliding nor surfacing feed can be thrown into action.

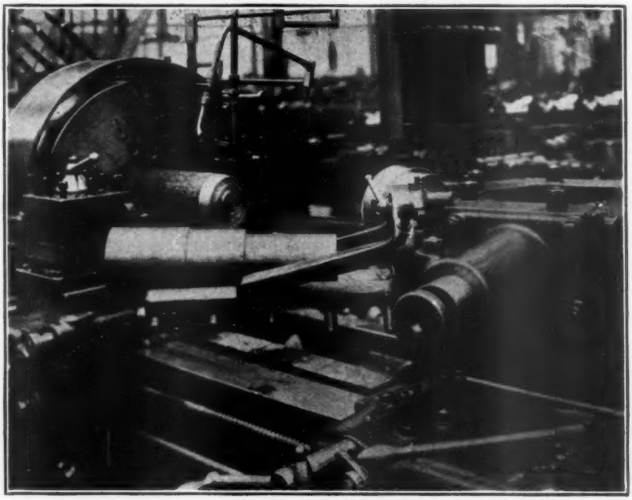

Fig. 3.—A turret cradle for supporting large work.

Capstan Lathes.

The range of work covered by a modern capstan lathe is so great that it is only possible to consider one or two points in connection

with this group of machines. Dealing first with bar work, it need hardly be mentioned that the automatic chuck fitted to capstan lathes has been developed to a high degree of efficiency. The Ward automatic ball operated chuck provides a good example of up-to-date design. In this case the whole of the mechanism is located at the front end of the spindle, thus eliminating the spindle tube which is otherwise necessary when the collet chuck is operated from the rear end. In this way the full diameter of the spindle bore can be utilised, thus increasing the capacity of the machine. In this particular machine, *i.e.*, the Ward 6½in. ungeared capstan lathe, the head is cast in one piece with the bed, a feature which on small machines gives increased rigidity with corresponding advantages in production.

Another feature is the provision of a swinging lever at the rear end of the headstock to facilitate the removal of chucks and fixtures from the spindle nose. This lever engages with a notched collar on the spindle, and, in addition to the purpose mentioned, it is exceedingly useful when employed with a drilling head mounted on the cross-slide. The cross-slide has the usual motions, whilst the turret slide also possesses important features. Thus the centre bolt is provided with a hole slightly larger than the holes in the hexagon turret to allow for the free passage of bars completely through the turret.

Usually the indexing of the turret is effected on the backward stroke by means of a ratchet attached to the face of the turret engaging with a finger attached to the bottom slide or bed of the machine, so that, by withdrawing the ratchet from its engagement, the automatic indexing motion of the turret is rendered inoperative. On the majority of capstans it is possible to take advantage of this to increase the length of the turret stroke for one tool only, and whilst this is useful it is of much more use if all the tools can be employed with the increased length of stroke. On the Ward 6½in. geared capstan this is effected by a quick hand withdrawing motion which disengages the indexing finger so that the turret can be revolved by hand when it is in its extreme backward position, the length of the stroke being increased by 3in. in this manner.

In the method of controlling the drive to machine tools, economies can be effected by the use of pedal-operated belt-changing gear such as that fitted on the Ward capstans. Examination of the cone pulleys in almost any shop will show that quite frequently only one of the speeds is used, despite the fact that changes of speed would increase the output. This difficulty can be overcome by making the operation of belt shifting as simple as possible, and in the mechanism referred to above, the change is effected by stirrups which entirely surround the belt and which are operated by levers coupled to three pedals by means of chains. The pedals are situated beneath the centre of the machine and are

fitted with a gate which retains the pedal depressed, and automatically releases those which are not depressed.

Capstan lathes lend themselves to the use of special equipment for obtaining a high output on special classes of work. The production of loco. firebox stays from copper bar provides a good example of this. This work is of interest, since the staybolts are reduced in diameter in the centre and are threaded at each end with threads which must be in pitch, *i.e.*, portions of a continuous helix. The stock used is approximatnely 1in. diameter, and the first operation consists in straightening the bar if necessary by forcing it while revolving into an eccentrically mounted cone. The centre portion of the bar is then turned to $\frac{7}{8}$in. diameter with a roller box turning tool in which provision is made for a lateral

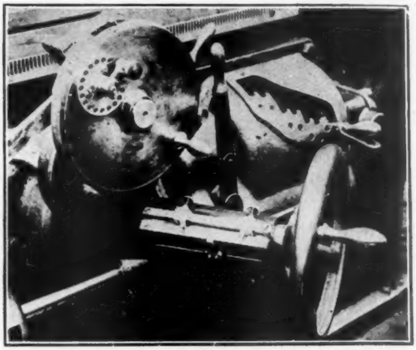

Fig. 4.—Quick hand motion fitted to grinding machine wheel head.

feed to the tool to enable it to pass the full diameter at the end of the bolt. During the traverse of this tool the cross-slide is actuated by hand to bring a double chamfering tool into action so that the rear end of the bolt is chamfered, together with the front end of the bar in the collet.

The thread is cut with a self-opening die-head mounted on an adaptor which also engages with a special lead screw geared to the work spindle. A cam retains the nut on the adaptor in contact with the lead screw until the required length has been threaded, when it is automatically disengaged, leaving the die head free to travel forward slightly until it is opened automatically in the usual way. The speed is then increased to minimise the time required in traversing the die head to the required position for threading the other end of the bolt, when the nut again engages the lead screw, thus producing a continuous thread. The stay

bolt is then cut off in the usual way, the entire operation on a 1in. bolt $5\frac{1}{2}$in. long being performed in between 35 and 40 seconds.

Combination Turret Lathes.

There is no doubt that one of the greatest improvements in these machines is the single-pulley all-geared headstock. This not only enables the required spindle speed to be selected with facility, but it effects enormous savings in installation, as countershaft gear is unnecessary. It is also admirably suited for individual motor drive, the constant-speed driving pulley ensuring the maximum horse-power being always available. A further advantage is that secondary drives, such as those to the pump, and such motions as the rapid idle traverse, automatic turret indexing, etc., can be easily arranged. The control of these machines has also been improved and centralised, the speed change levers being made interlocking, so that damage due to accidental or careless operation of the levers is impossible, whilst screw cutting, sliding, and surfacing motions are also arranged so that conflicting gears cannot be engaged.

A useful point on the Ward machine is a coupling on the saddle which connects with a bracket on the front of the turret slide. This enables the turret to be given a chasing motion for accurately controlling the pitch of coarse threads when produced by a self-opening die head, thus obviating the trouble which arises in correctly engaging the die head when it is necessary to take two or more cuts.

The fatigue occasioned by the operation of a large combination turret lathe has been considerably reduced, and output correspondingly increased by the adoption of quick power traverse and power indexing motions for the turret. The mechanism for this purpose is shown in fig. 2, in which N represents the feed shaft at the rear of the machine from which power is derived. Keyed to this shaft and carried in the traverse box is a collar clutch, Y, which can be clutched to either of two bevel pinions. These in turn drive a large bevel wheel connected to a pinion meshing with the rack Z at the rear of the bed. Safety trips are provided in both directions, and these operate directly on the clutch lever, thus forcing the clutch out of engagement if any obstruction is encountered.

The lever which engages the quick power traverse is provided with a cam plate engaging with another double lever so arranged that the large star wheel is disengaged and remains stationary whilst the quick power traverse is in action. Continued movement of the power traverse engagement lever effects the automatic rotation of the turret, the motion being obtained from the same feed-shaft by means of a worm, P, meshing with a worm wheel running idly on a vertical shaft. At its upper extremity this shaft is secured to a plate, Q, carrying pins, U, which engage with a

Geneva wheel, V. This is secured to a spur wheel, W, which drives through suitable gearing to the turret. Three notches are cut in the periphery of the plate Q to receive the trip plunger X. This is disengaged from the plate by the same lever that releases the turret and withdraws the index plunger, and at the same time

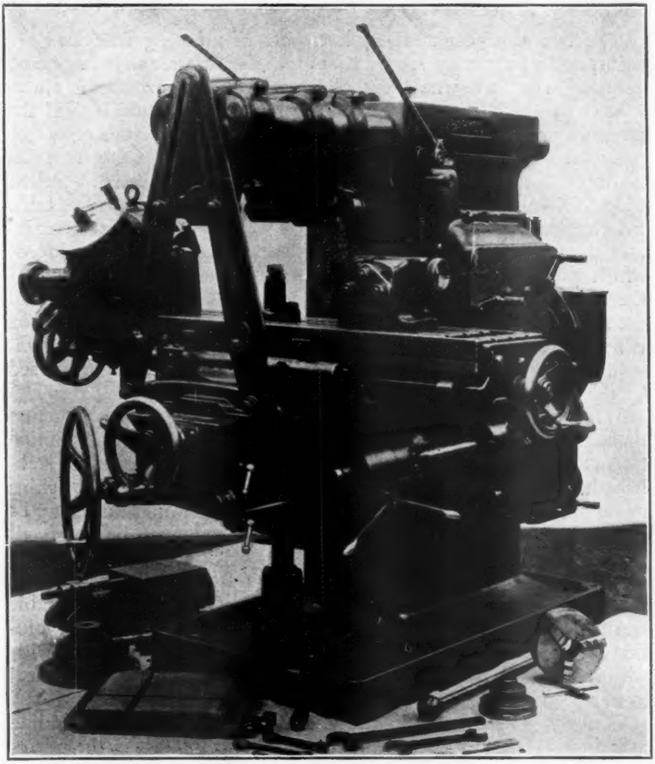

Fig. 5.—An example of improved rigidity in a milling machine.

the worm wheel is connected through the clutch of the vertical shaft.

An interesting item of tool equipment on a large turret lathe is shown in fig. 3. This illustrates a work cradle for supporting a locomotive crankpin. The cradle is bolted to the turret face and contains a number of pins which are adjustable in height to suit

the diameter of the finished piece. The pins can be set so that the cradle acts as a steady, and a heavy job may be parted off clean from the back tool post. The cradle also carries the work when parted off to the position most convenient for removing it from the machine.

Grinding Machines.

The two most essential requirements in grinding machines are accuracy and capacity for high output, the first requirement being accuracy, since the whole purpose of a precision machine is otherwise defeated. The initial accuracy must be maintained, and the machine must, therefore, be durable and as free from errors as possible. In this connection the merits of the travelling table as distinct from the travelling wheelhead may be considered. In the Churchill type of plain grinding machine, for instance, the table travels past a fixed wheel, and this feature alone tends to maintain the accuracy of the table ways. A long table is employed, which travels backwards and forwards over the whole length of the ways, and such slight wear as may take place is uniform and even. The importance of this will be apparent when a comparison is made with the ordinary lathe guides, which, as is well known, will in time become untrue on the part that is constantly traversed by the carriage.

With regard to the capacity for high output, it is production times that can be consistently maintained that matter. Exhibition tests or claims made under special conditions that cannot be established are of no consequence. As in previous types of machine tools, much depends upon the facility with which machines may be handled, and there are one or two special points to be observed. For example, the output of a grinding machine depends largely on the width of the abrasive wheel, providing always that suitable table speeds can be selected from the range. If possible, the table travel should equal almost the full width of the wheel per revolution of work, thus utilising to advantage the full width of a wide wheel, whilst at the same time obviating the tendency of the wheel to wear convex.

Controls have been admirably centralised in modern grinding machines. One device which is of particular interest is the mirror which is fitted to the wheel guard so that the operator has a clear view of the gap between the wheel and the work at the moment of making contact. This is particularly useful when grinding large-diameter work.

Another device which results in substantial economies is the quick hand motion which is fitted on all sizes of Churchill grinders from 6in. upwards. Ordinarily, the cross feed to the grinding wheel must of necessity be very fine for the work it is called upon to do, and this results in considerable loss of time when it is

necessary to transfer the wheel to a large diameter from a small diameter on the work, or *vice-versa*.

The quick hand motion enables the wheel to be moved quickly to and from the work, the device being fitted as shown in fig. 4. It consists of gearing introduced below the ratchet wheel feed, so that by means of an auxiliary shaft and handwheel a high ratio is obtained between the fine hand motion and the quick motion

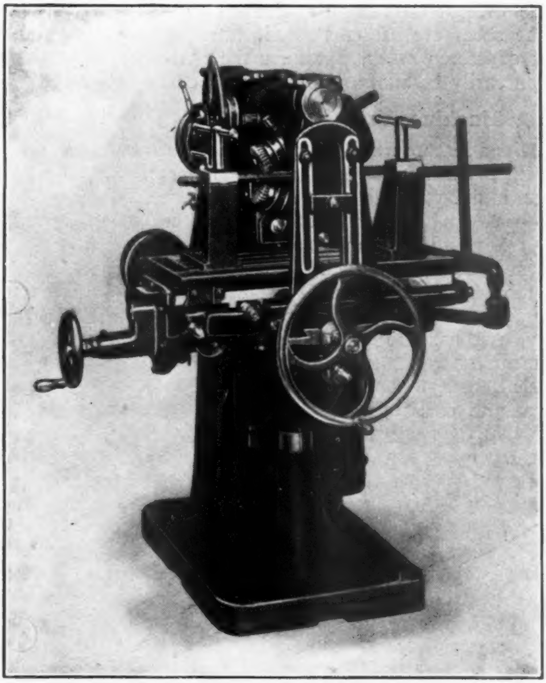

Fig. 6.—A machine specially equipped for mitreing sash bars.

An indicator is fitted to show the position of the wheel head so that the operator can bring the wheel from the large diameter to the small diameter without even looking at the position of the wheel.

The method of form grinding is attracting increasing attention as a means of improving production. The work may have different diameters which must be ground up to a shoulder, or it may be

necessary to grind a taper or any other specified form, the required profile being maintained on the wheel by a diamond truing device. The use of wide wheels with a direct in-feed is possible, since the power cross feed is independent of the table travel.

Steadies play a very important part in accurate grinding, and it is essential that they should be capable of rapid and easy adjustment whilst the work is proceeding. It is a considerable advantage if the steady can be used to the full capacity of the machine without changing the blocks or shoes. In the Churchill type the shoes are of hard wood, which not only eliminate any danger of scored work, but have the additional advantage that they can easily be adapted to the shape of the work in hand.

Milling Machines.

The chief feature which makes for increased or improved output in a milling machine is rigidity, and one method of obtaining this is shown in fig. 5, which illustrates a Parkinson No. 2 T Universal miller with double over arm. On very heavy cuts when using coarse feeds and high speeds, it has been found that the single over arm is not sufficiently rigid to eliminate chatter, particularly when the size of the work prevents the use of the outer arm brace. The construction shown not only gives greatly increased rigidity, but has the additional advantage of allowing various attachments, such as vertical milling components, rack cutting equipment, etc., to be conveniently fitted. It may be seen that the over arm consists of two cylindrical arms arranged side by side so that the centres of the arms and the centre of the spindle form a triangle.

Apart from the inherent strength of the two arms it will be apparent that for a given vertical distance between the centre of the spindle and the plane of the arm a larger cutter can be employed, or, alternatively, the same size of cutter may be employed whilst the vertical distance is reduced, thus, therefore, adding to the rigidity of the construction. The output or capacity of a milling machine may be considerably increased by the use of various attachments, and several of these were described and illustrated by lantern slides, including spiral milling equipment, a rack-cutting component, a rotary table, a slotting attachment, and precision boring or jig boring equipment.

An interesting example of a standard machine fitted with special equipment for turning out work in large quantities is shown in fig. 6. This illustrates an Archdale manufacturing milling machine arranged for mitreing steel sash bars. It may be seen that double mitres are milled simultaneously by means of two form cutters carried on spindles inclined at an angle to each other. These spindles are carried in an attachment fitted to the over arm and bolted to the body of the machine, the drive being taken through

a train of gears running in an oil bath. Provision is made for quickly removing the cutters for sharpening, and in operation they are set to the required positions, the lower head being provided with horizontal adjustment. The work is then mounted in a special fixture, and the cross feed to the table is used for the cut, the longitudinal traverse being employed to space the mitres.

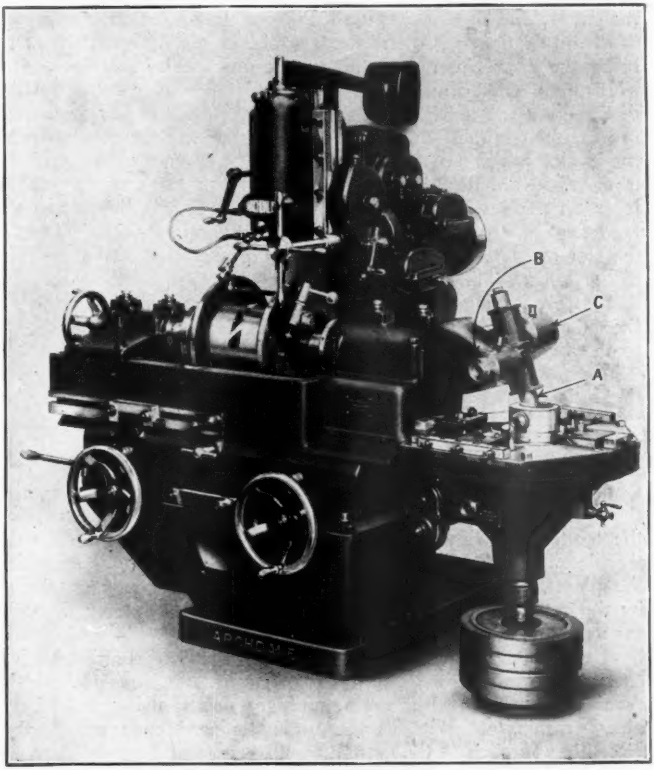

Fig. 7.—Milling ports in piston valve liners.

The success of repetition milling is largely dependent on the efficiency of the work-holding fixture, and in the case under consideration the fixture has been made to fulfil the necessary requirements. It is sufficiently rigid to withstand the heaviest cut that can be taken, it is fitted with two clamps which may be rapidly

operated by hand, and which are so arranged as to be practically unaffected by swarf, etc. This machine is of interest inasmuch as it illustrates another feature which is of great value in increasing the output from a milling machine. Much time is frequently wasted by the operator engaging the power feed to the table when the work is some distance from the cutter. It is common practice to use a quick traverse to bring the work within about $\frac{3}{4}$in. from the cutter, and then to engage the power feed, since the operator is afraid of damage to the work or the cutters if he attempts to bring the work closer than this by the quick hand motion.

In the machine illustrated means are provided for automatically disengaging the quick traverse and engaging the power feed at a predetermined point quite close to the work. For this purpose the mechanism shown towards the left at the front of the table is utilised. Normally the feed is engaged by means of the clutch lever on the left, and when it is required to use the automatic feed engagement, a plate carrying a tumbler is adjusted along a tee slot on the front of the table to the correct position relative to the work. The tumbler on this plate is arranged to make contact with a spring plunger in a pivoted box as shown, whilst on the other side of the pivot the box is fitted with a projecting tooth which bears against the lower edge of the adjustable plate.

When the work is being moved quickly towards the cutter by the quick traverse motion, the power feed is, of course, disengaged and the quick traverse is continued until the plate is over the pivoted box and in such a position that the tumbler compresses the spring in the box by means of the plunger. The tendency now is for the box to swivel about a pin and so engage the clutch to throw in the power feed, but this is prevented by the tooth previously mentioned making contact with the face of the plate. As, however, the continued traverse of the table carries the plate past the projecting tooth the pivoted box is oscillated by the required amount to operate the clutch and lever through the medium of a longitudinal rod. The utility of this device may be best illustrated by considering the actual time saved, for example, in milling magnets of 10 per cent. tungsten steel which require a work travel of $2\frac{1}{2}$in. and are milled using a feed of 2in. per minute. Without the automatic feed engagement, the $\frac{3}{4}$in. idle approach to the cutters would represent a waste of more than 20 seconds per load, or 30 per cent. of the actual cutting time.

Another machine utilising special equipment which has many features of interest is that shown in fig. 7. This shows an Archdale vertical milling machine arranged for milling the ports in piston valve liners without the necessity for previous marking out. The machine resembles a vertical miller in construction, except that the ordinary table is replaced by a substantial box body

carrying the special headstocks, together with the indexing and profiling mechanism. The work-holding and driving mechanism is carried on a self-contained slide, but has longitudinal traverse from a subsidiary slide on the box bed. This lower slide has transverse traverse on the bed, the respective motions being controlled by means of two handwheels shown. The spindles of the headstock and tailstock are also arranged to slide longitudinally on their own axes, this motion being controlled by a cam which generates the profile of the port. It will be appreciated that

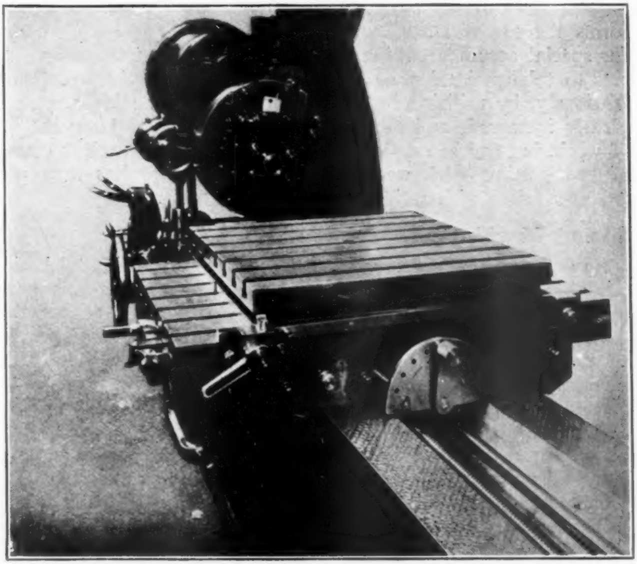

Fig. 8.—A boring machine fitted with squaring lock and screw cutting adjustment.

when the work-holder and work are mounted in position, the spindle on which it is carried is to all intents and purposes a solid shaft, and the longitudinal movement mentioned above is combined with a rotary oscillating motion according to the shape of the port required.

Gear Planers.

The subject of gear cutting machines would require a special paper to deal with it anything like exhaustively, and it is only

possible to mention one or two points connected with a typical machine. Output is increased and the quality of the work is improved on machines like the Sunderland gear planer by utilising double cutting cutter boxes. These permit the use of two cutters placed back to back so that one operates on the forward stroke whilst the other cuts on the reverse stroke of the slide. The box is pivoted so that it oscillates at the end of each stroke to present each cutter in turn to the work.

In practice it is found advantageous to employ one cutter for machining the bottom of the tooth space, and the other for finishing the sides of the tooth. The "bottoming" cutter thus performs the heaviest and least important work and does not call for special accuracy, whilst the finishing cutter having only light cuts to take maintains its condition for some considerable time. Obviously, by utilising both strokes of the cutter slide, output is greatly increased, and the method is not limited to large batches of work, but can be employed for single wheels. Various classes of gear-cutting work were described, and the author then proceeded to deal with reciprocating machine tools.

Boring Machines.

Some interesting features were pointed out on horizontal boring machines of the Pearn Richards type, mention being made amongst other details of the patented squaring lock and of an accurate device fitted to the table to facilitate the adjustment of the cut when screw cutting. These features have been incorporated on the machine illustrated in fig. 8, the screw-cutting adjustment being obtained by means of the small lever shown in the centre of the table. This is coupled to the nut which engages with the lead screw, so that the nut may be rotated through a small angle to move the table by the amount required to put on the cut. The lever moves over a dial graduated in thousandths of an inch.

The patented squaring lock is designed for use when exceptional accuracy is required. Ordinarily, of course, indexing of the revolving table is sufficient, but the squaring device provides for a higher degree of accuracy, and is unaffected by wear. It consists essentially of a wedge which bears against the whole length of the table on one side, the tapered edge being in contact with inclined faces on two brackets attached to the main table. The wedge is actuated by a lever and rack and pinion, and when forced home it locates the table in any one of the four positions with precision.

Another useful device which can be fitted to the same type of machine is the flange drilling attachment shown in fig. 9. It frequently occurs that a number of equally spaced holes have to be drilled around the various flanges, bosses, etc., on work which is set up on the machine for the main boring operations. The attachment is made with a circular base which is carried on the slide of

the facing head of the machine, and the drill can be accurately set to the required radius by rotating the bracket carrying the drill spindle, the circular base being graduated for this purpose. The drive is taken from the live traversing spindle, which has an independent range of speeds, and the spacing of the holes is obtained by indexing the boring head in the required position.

Much could be said regarding multiple drilling machines as a means of increasing output, but it is only possible to give one or two examples of this class of equipment. Frequently work which

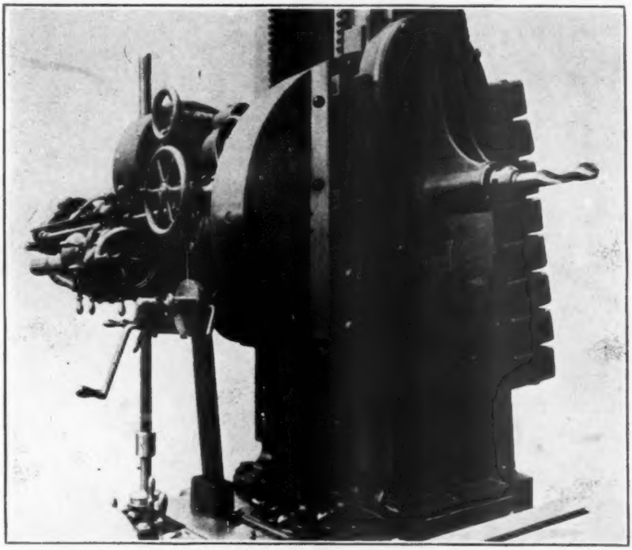

Fig. 9.—Flange drilling attachment for boring machines.

would not ordinarily be carried out on a multi-spindle machine can be dealt with very effectively if proper fixtures can be provided. For example, in drilling connecting-rod bolt holes, it is usual to handle the components one at a time using a two-spindle or four-spindle head. Compared with this, the method adopted by one of the largest automobile manufacturers in the country is of interest.

The equipment employed is illustrated in fig. 10, which shows a special indexing fixture fitted to an Archdale machine for accommodating eight rods simultaneously. There are three operative stations at which the respective operations of drilling and reaming are carried out, whilst the fixture is loaded at the fourth station.

The jig plate is carried by the drill head being mounted on spring posts so arranged that when the plate makes contact with the work the automatic feed is engaged, and the spring posts then

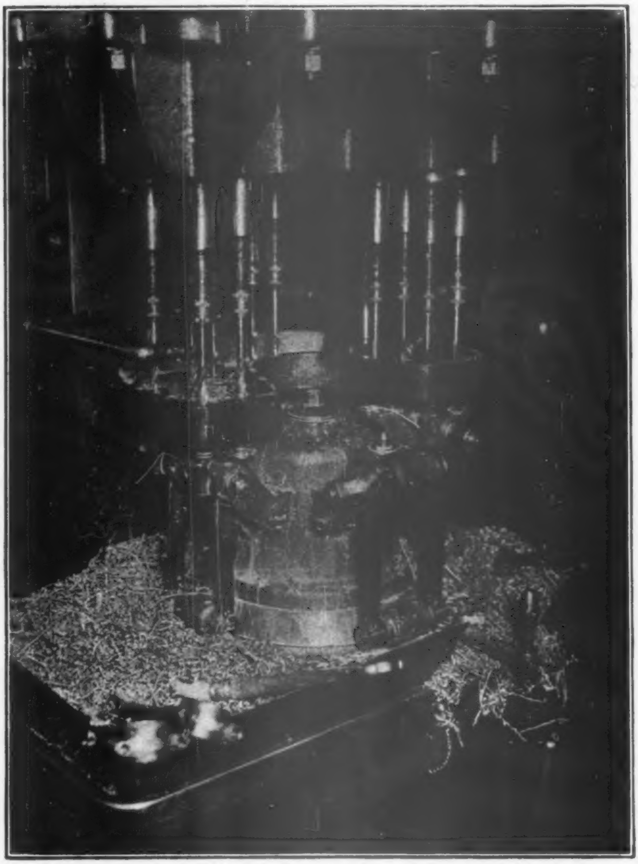

Fig. 10.—A multi-spindle machine used for drilling connecting rods.

slide in bearings in the head of the machine until the required depth has been drilled. When the drill head is raised away from the work the jig plate, of course, travels vertically with it.

Another interesting item of special equipment is shown in fig. 11, which illustrates a machine built for drilling small holes in tubes of special form. One of these tubes is shown at the base of the machine, from which it may be seen that they are flat on the top and have a raised rib running down the centre. They are made from material 0·049in. thick and drilled with three rows of holes equally spaced, the total number of holes being 226. Whilst the

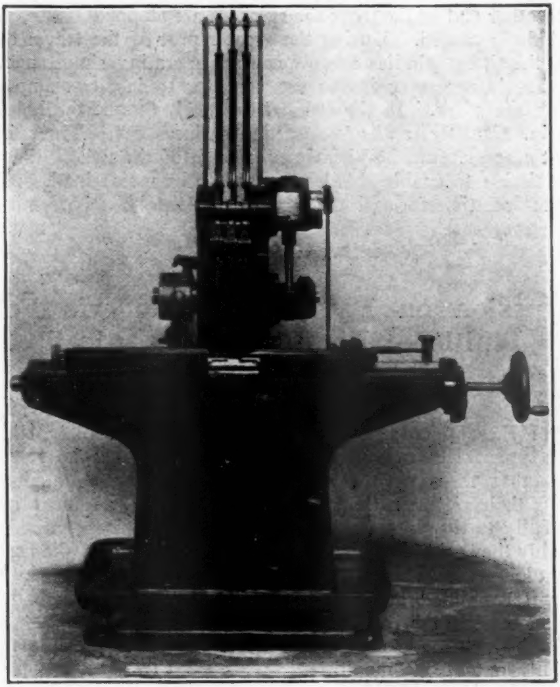

Fig. 11.—A light high-speed drilling machine for special work.

machine is naturally of a special character, it is not limited to the work in hand, but is suitable for any similar work requiring a large number of holes spaced equally in rows.

The close spacing of the holes renders it impossible to mount the three spindles in line across the face of the work, so that the following interesting construction has been adopted. The spindles are located at a longitudinal distance apart equal to a multiple of

the pitch of the holes, whilst they are arranged transversely for drilling the respective rows. The machine is entirely automatic in operation, the table being indexed by means of ratchet mechanism, whilst the drive and feed to the respective spindles are so arranged that the action of the second and third spindles is delayed whilst the first few holes are drilled by the first spindle. Each spindle, in fact, commences as soon as the work reaches the correct position for drilling the first hole in the row over which it is located, and at the other end of the work the spindles are stopped in turn as the last hole is passed. During the greater part of the travel of the table the three spindles are, of course, operating simultaneously. All that is necessary is for the operator to insert, clamp, and remove the work. In the case of the work shown, the holes are 0·093in. diameter, and are spaced 0·312in. apart. The spindles run at 4,200 r.p.m., ball bearings being fitted throughout the main transmission to enable this high speed to be maintained, and the floor-to-floor time for each piece containing 226 holes is 2½ minutes.

Discussion on Mr. A. H. Mundey's Paper Entitled "Die Casting Practice."

Mr. R. H. Hutchinson.

THE President, in opening the discussion, said he did not propose to say much at that stage, because he felt sure that there were a number present who were anxious to express their views on the subject of die casting. After alluding gracefully to the presence of ladies, the President remarked that probably they could tell the members something about die casting, for undoubtedly some of the earliest die castings with which we became acquainted in life were those made by our mothers and grandmothers in the form of jellies. These were cast in wonderful moulds, which made us wonder how it was ever possible to get the jelly out of the mould.

Mr. Mundey said that there were really no mysteries in die casting practice. What he meant, in stating, in his opening remarks, that the subject was wrapped in mystery was that to the uninitiated there were many little points which appeared mysterious. There were one or two points upon which we would like further information. One was with regard to the direction of cooling or freezing of the metal. He would like to know whether the question of the direction of freezing had to be considered very seriously in the design of the various parts of the die. Was it possible that the cracks and other defects, which

were more evident in die castings than any ordinary castings, were partly due to the fact that insufficient attention were given to this point? The relative expansion of heating and contraction of cooling of the casting and of the die seemed to him to be a possible source of trouble unless it were provided for.

Another point with regard to the same matter of ageing cracks was whether any form of heat treatment was advocated. He was, of course, aware that many of the metals were of a fairly low melting point, but, even so, some metals might be heat treated by boiling in brine.

With regard to the alloys used, we know that L.8 alloy has been used extensively, and one wonders why the alloy known as L.5 is not more successful in die casting.

With reference to casting under pressure, there are quite a few plants in which the air is introduced through the centre of the pot, and he had never been able to understand what was in the minds of the designers in not taking the metal from the bottom of the pot instead of from the top. There were various other points which he had in mind, but he had mentioned the above in order to open the discussion.

Mr. Mundey referred to the President's remarks as to the mystery of the jelly moulds. He said that undoubtedly the direction of cooling and freezing had to be very carefully considered and the greatest attention given to the design of the part and of the moulds with respect to contraction.

With regard to the possibility of overcoming age cracking by heat treatment, boiling in oil or brine, etc., this was possible and was done in many cases. Cost was an important factor, however, and the average manufacturer was not willing to make sufficient allowance for the expense of subsequent operations of this character.

In connection with alloys, L.8, being composed of aluminium and copper, lent itself to die casting, but L.5, having a large percentage of zinc, became troublesome from several points of view. The production of very hard aluminium-zinc constituents tended to cause cracking, and the zinc at this temperature was troublesome in other respects.

Mr. Yates said he had listened with pleasure to the lecture, and was more especially interested in the remark that aluminium could not be successfully cast under pressure. He suggested that this was really a matter of experience, and was probably only an extension of the experience gained in the casting of zinc base alloys.

With regard to the types of machines which had been shown, and more particularly the Zoss machine, was this machine a modern one, and was it one which was used in the lecturer's own works? Mr. Yates commented on the sprue cutter, remarking

that he did not think the sprue was in any way essential; it was rather old-fashioned and could be done without quite successfully.

In reply to Mr. Yates's remarks, Mr. Mundey said he did not mean to convey that aluminium could not be cast under pressure, but the temperature at which the aluminium alloys were molten made the use of a piston and plunger very difficult, if not impossible. A very large number of aluminium castings were being turned out, but there was a considerable percentage of failures from various causes. He did not intend to infer that aluminium pressure casting could not be done. It was being carried out in Birmingham, and also largely in Germany and America, and he was prepared to be a prophet and say that it would be much more extensively employed in this country. It was certainly within sight, but the apparatus was expensive, and one had to consider capital cost in connection with these operations, or they were not a commercial proposition. We must be content to make haste slowly.

With regard to the Zoss machine, they had one in their factory, but they did not use it at present. It was beautifully ingenious, but was apt to be a little troublesome. The machines which they were using with considerable success were those which had been illustrated in the paper; although it might appear as if the sprue cutting arrangement was primitive and simple, it was exceedingly effective. It was probable that not many years would pass without further improvements.

Reverting to the question of the mystery surrounding the subject, Mr. Mundey said that he was sorry that he appeared to contradict the Chairman. What he really meant was that, whilst there were such things as trade secrets, these were not things which were stored up in the manager's safe, but were rather in the hands of designers and operators. Even the man who was doing the job could not quite explain them; it was just a tricky job which one got to know by experience.

With reference to the question of cooling and freezing, the designer must be most careful to avoid changes of form, abrupt changes of sections, corners, or angles, in which the direction of cooling would be such that the casting would pull itself to pieces in the mere process of crystallisation. The formation of crystals was particularly important in an alloy such as L.5, which contains some 12 or 13 per cent. of zinc. Crystals of aluminium and zinc grow in very definite forms and are absolutely glass hard. Moreover, the formation of the crystals goes on after the casting has solidified. One can easily understand how the growth and movement of the zinc aluminium crystals tears the remainder of the metal mechanically and gives rise to the effects mentioned.

Mr. Marston (Member) remarked on the audacity of the Institution on having attempted to deal with such a big subject in

one evening. The whole evening could be spent discussing the action of various metals on one another. He was particularly interested in die casting in aluminium, having produced such castings more than seven years ago. At that time the trouble was the expense of the dies, not only in first cost, but in maintenance.

Mr. Marston referred to the question of the peculiar skin effect which was produced on the die, particularly when there were small cores, which, in many cases, had to be made collapsible in order to get them out. With regard to the limitations of the die casting, on the score of expense or limited quantities, he maintained that there was no royal road to successful practice. He quite agreed that it was not necessary to have a sprue at all, and, in any case, considerable attention was necessary in determining the position of the sprue. It was a fairly safe rule to fill the die from the bottom.

Commenting on the shape and length of the venting, Mr. Marston mentioned a very interesting point in controlling efficient venting by careful observation of the whistling noise due to the exit of the air. Speaking of the crystalline structure of certain alloys, he thought a fine example of crystal formation could be observed by the well-known experiments of bismuth. Another matter in which he was interested was the pressure used in casting. This was very variable—sometimes as much as 200 lb., and in other cases only 80 lb. per square inch. The differences to be observed were not so great as might be expected. Many people regarded die casting as a proposition which could only be successful if large numbers had to be produced. He had found it possible and economical to work with quite small numbers.

With reference to the question of the cooling of the dies, Mr. Marston mentioned that the Monotype Caster was, in his opinion, the most beautiful example of efficient cooling.

Mr. Mundey answered most of the points which Mr. Marston had raised. In the course of his reply he pointed out that it was not only the mere crystalline structure of metal used, but that certain crystalline constituents fell out of the solution on cooling, and that the alloys were not homogeneous, and, therefore, required special care in their manipulation. He was interested in the whistling noise due to the ejection of the air as described by Mr. Marston, but he felt that in a noisy shop this test might not at all times prove reliable, but quite agreed as to the great ingenuity and excellence of the die casting as exemplified in the Monotype caster.

Mr. Ford referred to the difficulties in connection with obtaining a satisfactory enamel finish on die casting. The heat treatment sometimes involved overheating, and he wondered whether any better methods could be devised to overcome this.

Mr. Mundey explained that frequently enamelling stoves were

overheated, despite the thermometer control. This produced a kind of sweating of the casting, on account of the low melting point of certain constituents. The trouble could, however, be obviated by more careful temperature control, since there was no need to raise the temperature to such an extent in enamelling.

Mr. Martin remarked on the beautiful castings which had been exhibited by the lecturer as examples, and said he feared that some firms did not pack their castings sufficiently well. This was not a practical question, but it was very important, since many good castings became ruined in transport, involving a waste of money, time, and trouble.

Mr. Yates again spoke, emphasising the lecturer's remarks for the necessity of mutual co-operation between designers and production engineers. He said there was no doubt that ample information had been accumulated as the result of experiments in America and Germany on the behaviour of metals in their fluid condition. He also reiterated that aluminium die castings were often quite as easy to produce, besides being better than those made from zinc base alloys.

The President concluded the discussion by thanking the lecturer for such an interesting evening. He hoped that it was only the first of many evenings, as he was sure that members would welcome another evening to continue the discussion. It was particularly refreshing to listen to a lecturer who was so full of his subject that he could talk in detail on all the various points in the way in which Mr. Mundey had done.

The meeting terminated in a hearty vote of thanks to Mr. Mundey.

EMPLOYMENT BUREAU.

Members are asked to do all in their power to make the Employment Bureau a useful feature by forwarding particulars of positions likely to be of interest to those who are seeking new situations.

Member, specialist in the design and production of tooth gearing, is disengaged, and will be very pleased to hear of suitable position.—Write, Box No. 13, c/o Hon. Sec.